SLOVENSKI STANDARD
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Aditivna proizvodnja kovin - Splošna načela - Registracija geometrijskih podatkov, pridobljenih pri spremljanju procesa in za nadzor kakovosti (ISO/ASTM DIS 52953:2023)

Additive Manufacturing for metals - General Principles - Registration of geometric data acquired from process-monitoring and for quality control (ISO/ASTM DIS 52953:2023)

Additive Fertigung von Metallen - Allgemeine Grundsätze - Registrierung von Geometriedaten aus der Prozessüberwachung und zur Qualitätskontrolle (ISO/ASTM DIS 52953:2023)

Fabrication additive de métaux - Principes généraux - Enregistrement de données géométriques acquises à partir de la surveillance du procédé et pour le contrôle qualité (ISO/ASTM DIS 52953:2023)

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Additive manufacturing for metals — General principles — Registration of geometric data acquired from process-monitoring and for quality control

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 261, Additive manufacturing, in cooperation with ASTM Committee F42, Additive Manufacturing Technologies, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on Additive Manufacturing.

Introduction

Additive manufacturing (AM) is the general term for those technologies that successively join material to create physical objects as specified by its 3D design model data. Current AM technologies can fabricate parts layer-by-layer using different material types as inputs. The resulting parts have complex geometries that are needed for applications in a variety of manufacturing industries, where AM parts offer significant advantages or where the parts cannot be made using the traditional manufacturing technologies, such as machining and welding.

AM machines are being instrumented with various types of sensors which collect data throughout a build. Often, each sensor is designed to collect only one type of measurement dataset in a unique coordinate system. The use of this monitoring data for applications such as qualifying AM components is enhanced when a diverse range of sensor datasets are used and compared to post-process inspection. This requires multi-modal dataset registration including data alignment.

Registration of these datasets consists of recording necessary metadata and data alignment. A registered dataset allows the extraction of features from data from different sensors to be appropriately registered to post-process inspection. These features may be used for a range of applications including to control variations in powder spreading, melt-pool geometry, thermal stability, layer integrity, defect detection, and part quality.

It is the intention of this document to provide a procedure and methods to register AM data, including:

a) associating validated data with known time, locations, and origin, and

b) data alignment for process monitoring and control.

Laser-based powder bed fusion for metals (PBF-LB/M) is used to demonstrate the data registration procedure. The procedure can be applied to monitor other AM processes, such as direct energy deposition, polymer or ceramic powder bed fusion, binder jetting, and photopolymerization.

Additive manufacturing for metals — General principles — Registration of geometric data acquired from process-monitoring and for quality control

1 Scope

This document sets and defines the minimum requirements for registration of data acquired from process-monitoring and for quality control in additive manufacturing (AM), including the description of a procedure.

Furthermore, this document comprises actions that users shall execute to register multi-modal AM data and store them in an appropriate repository.

This document is not applicable for data cleansing, image processing, cost, production time and personnel.

This document is only applicable for data gathered and generated from non-destructive test methods and sensors, e.g., X-ray computer tomography (XCT), cameras and coordinate measuring machines (CMM).

This document is only applicable to metallic parts produced by means of laser-based powder bed fusion (PBF-LB) and direct energy deposition (DED); nevertheless, the procedures described in this document can be applied to monitor other AM processes and materials (e.g., polymer or ceramic powder bed fusion, binder jetting, and photopolymerization), but this document does not provide any data or case studies for them.

2 Normative reference

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
data alignment
process of transforming different sets of geometrically or temporally related data into a single, common coordinate system

3.2
data registration
procedure of aligning data, recording metadata, and assigning a persistent identification to the aligned data set

3.3
digital imaging sensor
detection device, usually photoelectric, that captures photographic images of an object in a digital format

Note 1 to entry: It is also called a digital, visible-light-imaging sensor.

3.4
digital infrared (IR) imaging sensor
digital imaging sensor sensitive to infrared light spectrum.

Note 1 to entry: It is also called a digital, thermal-imaging sensor.

3.5
ex-situ inspection
measurement or examination performed on the workpiece after it is extracted from the build chamber

Note 1 to entry: The inspection can be destructive if the workpiece is a coupon for mechanical testing or a sample for microstructural analysis

3.6
fiduciary mark
physical mark on a build plane or a layer to locate the scan tracks relative to the image coordinate system

3.7
global coordinate system
unique coordinate system to which all the data is referenced

3.8
in-situ measurement
measurement performed on the workpiece when it is being processed in the build chamber

3.9
staring configuration
type of sensor configuration wherein a non-contact sensor is mounted within or outside the build chamber, such that its field of view is fixed with respect to the machine coordinate system

Note 1 to entry: Also known as fixed position, lateral configuration, off-axial.

3.10
staring camera
a camera that is installed in a staring configuration used for layer-wise imaging or melt-pool imaging.

3.11
layer image
image of the layer taken by a staring camera

3.12
melt pool image
image of melt pool taken by either a coaxial camera or a staring camera.

3.13
X-ray computer tomography (XCT) three-dimensional (3D) model
3D model constructed using sets of two-dimensional (2D) images of an XCT-scanned part.

3.1 Abbreviated terms

2D	Two-dimensional

3D	Three-dimensional
AE	Acoustic emission
CAD	Computer-aided design
CCD	Charge-coupled device
CMOS	Complementary metal oxide semiconductor
CS	Coordinate system
HIS	Hyperspectral imaging
ID	Identification
LIPS	Laser-induced plasma spectroscopy
LUS	Laser-induced ultrasonic
LZW	Lempel–Ziv–Welch
MPE	Maximum permissible error
OCT	Optical coherence tomography
PBF-LB/M	Laser-based powder bed fusion for metals
SD	Sphere distance
TIFF	Tag image file format
XCT	X-ray computer tomography

4 Significance and use

This document provides methods and procedures for users to register measurements and associated metadata that they need for accurately qualifying complex metal additive manufacturing (AM)-built parts. Registered data satisfies additional three user goals: detect AM process instabilities, predict their impact on the part quality, and implement process control if needed and possible. Registered data can be from the following methods: in-situ photogrammetry, thermography, pyrometry, ex-situ XCT, CAD models and the associated metadata. These data sets are generated from a variety of sources, e.g., melt-pool images, scan paths, layer images, and XCT 3D models.

This document enables the development of data registration software. The software can help users register the data needed to validate the AM system states, optimize process parameters, and control part quality. Data analytics and control software can be modified to use registered data extensively from a wide range of measurement instruments, primarily imaging sensors.

5 Data registration procedure

As shown in Figure 1, the data registration procedure shall start with capturing metadata, which has the information about sensors and their settings (see Clause 6). Then, in-situ and ex-situ sensing, data cleansing, and assigning identification to data shall occur in that exact sequence. Data identifiers should be assigned according to ISO/IEC 9834-8 or a company-specific scheme. Data alignment includes both temporal and spatial alignment. Spatial alignment shall convert sensor data from its original, local coordinate system to a global coordinate system in which all the data can be compared and fused correctly. Aligned data sets are used as inputs to data analytics software that makes predictions needed for decision making and control.

Although data cleansing is out of scope, it can be a part of data registration.

Some examples of data cleansing in an image include, but are not limited to, correction of scaling because of perspectives, correction of distortion because of lens geometry, handling of insensitive/dead pixels, offset gain from laser speckles, denoising, and gamma correction. Image processing is out of scope.

Some examples of image processing for images include, but are not limited to, thresholding, spatter removing, plume removing, and XCT artifact removal.

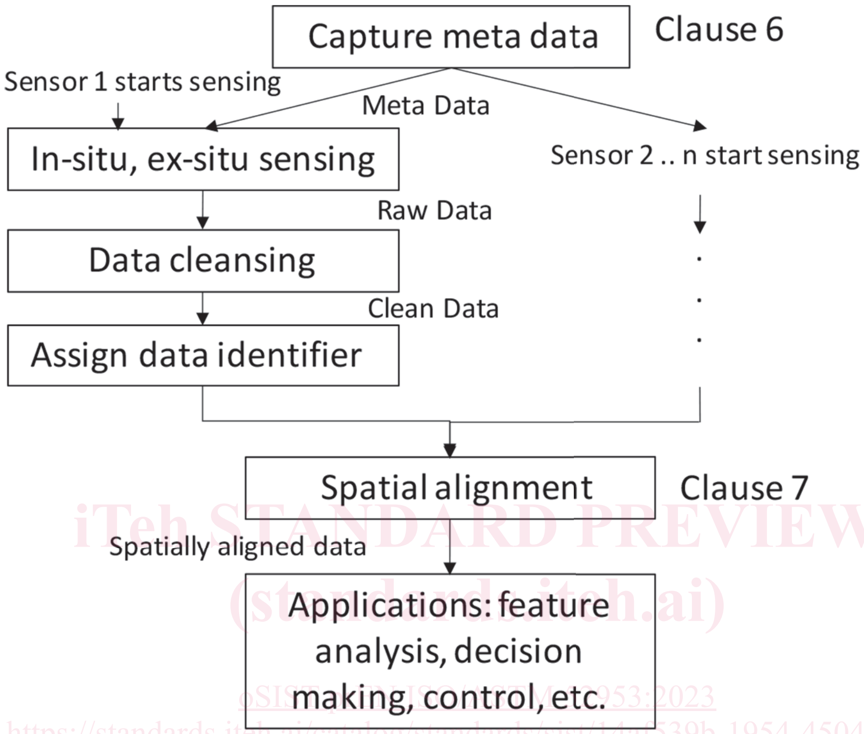

Figure 1 — General data registration procedure

6 Sensor categorization and metadata items

6.1 Sensor categorization

For developing a data registration procedure, a categorization of the current use of sensors for in-situ monitoring and ex-situ inspection is included in this clause. For more details, see Annex A. XCT coordinate measuring machines as ex-situ measurement instruments are also included in Annex A.

6.2 Metadata in in-situ measurement

6.2.1 Laser-scanning-related data elements

Laser-scanning-related data elements shall provide spatial references for the spatial alignment of in-situ measurements from different sensors. The scanning strategy registration method, which is process oriented, is based on the scan, laser-spot positions, laser power, and camera-trigger timing. This method shall be used primarily to register the position and the time when the image is taken by a camera. Required data elements are shown in Table 1.

